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Skid Road Recontouring in Southeastern British Columbia: 7-year Tree Growth Results

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Ministry of Forests Forest Science Program

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Pamela Dykstra and Mike Curran

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ABSTRACT

The *Forest Practices Code of British Columbia Act* (1995) created a legal requirement for soil conservation and, in particular, called for skid road rehabilitation to restore site productivity and slope hydrology. A research trial, initiated in the Nelson Forest Region in 1995, tested the efficacy of rehabilitation practices by quantifying tree growth on rehabilitated skid roads. This technical report presents the 7-year tree growth results of the study.

Sites were planted with lodgepole pine (*Pinus contorta*), or Engelmann spruce (*Picea engelmannii*), or both. At eight locations in the Rocky and Purcell mountains in southeastern British Columbia, total height, annual height increment, and basal diameter were measured on 1713 trees, which ranged in age from 6 to 10 years.

Undisturbed trees and those on berm locations grew significantly ($p<0.05$) more than those on inner track and midroad locations at the current block age for total height, 3-year increment, diameter, and volume for lodgepole pine. At a comparison block age of 7 years, 3-year increment was significantly greater for both undisturbed and berm-grown pine and spruce; additionally berm and undisturbed total height was greater for spruce. The growth of inner track pine trees was significantly reduced for all variables at the current block age. Reduced tree growth was most pronounced at sites with calcareous soils.

Continued poorer growth observed on the skid roads in this study supports the FPC requirement for more intensive rehabilitation methods to restore site productivity. Until it is demonstrated that the construction and rehabilitation of skid roads is sufficient to support acceptable tree growth, net downs to Annual Allowable Cut calculations may be necessary to address reduced tree growth on temporary access structures.

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1 INTRODUCTION

The *Forest Practices Code of British Columbia Act* (1995) created a legal requirement for soil conservation and, in particular, called for skid road rehabilitation to restore site productivity and slope hydrology (Province of British Columbia 1995). The method of skid road rehabilitation was not specified in the Forest Practices Code (FPC), and the evaluation of restored site productivity was left to the discretion of district managers.

Only a few forest companies in the East and West Kootenays undertook the rehabilitation of skid roads before implementation of the FPC. At that time, rehabilitation generally consisted of simply pulling back the sidecast material to recontour the slope. A study was initiated in the Nelson Forest Region in 1995 to quantify tree growth on these rehabilitated skid roads (Figures 1 and 2) and to test the ability of this type of rehabilitation to meet FPC requirements for restored site productivity. The FPC has since been amended to reflect, among other factors, the earlier findings of this study. Skid road rehabilitation techniques are now more specifically defined in the Timber Harvesting Practices Regulation (B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks 1998).

This technical report presents the tree growth results from the seventh-year measurement of this study. The experimental method and 1996 tree growth results are discussed briefly. Greater detail is provided in a journal paper (Dykstra and Curran 2000) and a previous research summary (Dykstra and Curran 1999).

2 METHODS

2.1 Site Description

The study sites selected represented a range of growing conditions, with climatic variation incorporated through the inclusion of sites in several biogeoclimatic subzones or variants (Braumandl and Curran 1992). The sites chosen included retrospective sites that were operationally planted or naturally regenerated after rehabilitation, and experimental installations in which the

FIGURE 1 *A 1996 photo of a rehabilitated skid road at the Grave Creek North site, blue stakes mark the planting locations from upper undisturbed down to lower undisturbed.*

trees were strategically planted on the various skid road positions described by Smith and Wass (1979, 1980, 1994) (see Figure 2). The sites in the western ranges of the Rocky Mountains included Lussier River, East Lussier Creek, Dry Creek, East Grave Creek, and North Grave Creek. The Bloom Ridge site, and Caven and McMurdo creek sites are in the Purcell Mountains (Table 1).

2.2 Plot Selection and Layout

All plots were originally contour skid roads that branched off a main skid road. Two representative sections of skid road within each retrospective cutblock were selected during a reconnaissance walk-through; often these were the only areas of adequate size to study. To have one upper and one lower skid road, the second section of skid road was selected relative to the position on the slope of the first. To avoid the influence of excess disturbance and potential hydrologic effects at the skid road junction, plots were offset 5–10 m from the main skid road. The rehabilitation treatment consisted of recontouring (replacing) the sidecast material.

Eight sites were planted with lodgepole pine (*Pinus contorta* Dougl. ex Loud.) (Pl), or Engelmann spruce (*Picea engelmannii* Parry ex Engelm.) (Se), or both (see Table 1). On each of the two skid road sections per study site, a minimum of 15 trees were measured on each of three locations corresponding to the previous skid road—inner track, midroad, and berm/

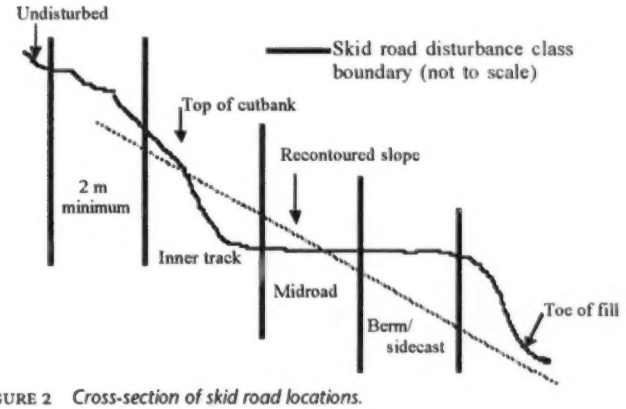

FIGURE 2 *Cross-section of skid road locations.*

TABLE 1 *Study site description*

Study site	Retrospective or established trial	Species (year planted)	Biogeoclimatic subzone[a]	Elevation (m)	Slope (%)	Aspect
Grave Creek North[b]	Established	Pl, Se (1992)	ESSFdk	1760	40	N
Grave Creek East	Established	Pl, Se (1992)	ESSFdk	1760	40	E
Lussier River	Retrospective	Pl (1990)	ESSFdk	1530	40	SW
East Lussier Creek	Established	Pl (1994)	ESSFdk	1760	50	N
Dry Creek	Established	Pl (1993)	ESSFdk	1720	45	S
Bloom Ridge	Established	Pl (1993)	MSdk	1440	45	W
Caven Creek	Retrospective	Pl (5–9 years)[c]	MSdk	1110	35–50	N
McMurdo Creek	Retrospective	Se (1991)	ESSFwm	1700	40	N

a Braumandl and Curran (1992)
b Grave Creek has north and east aspects, which are considered separate sites.
c Caven Creek is a naturally regenerated site; ages are from 1995 measurement.

sidecast—and on the adjacent undisturbed area (Figure 2). Inner track trees were located within 1.8 m of the top of the cut bank. Midroad trees were located 1.8–3.0 m from the top of the cut bank. Berm trees were located 3.0–4.5 m from the top of the cut bank. Because of the low stocking in undisturbed areas, these trees were sometimes located 5–10 m away from the skid road. Total height, annual height increment, and basal diameter were measured on 1713 trees.

2.3 Analysis

Three-year height increment, total height, volume, and diameter were analyzed using analysis of variance (ANOVA) under a randomized complete block design. Each site and species combination acted as a statistical block and the rehabilitation treatment consisted of four levels (undisturbed, inner track, midroad, and berm/sidecast). Statistical contrasts (means comparison tests) were used to compare different treatments (disturbance types); no correction was made for the number of contrasts performed. Volume was calculated as 1/3 (area of the base × height). The analysis was performed at the current age of each block. To establish a relative age to compare growth results,[1] height at age 7 (7 years after outplanting) was also analyzed.

3 RESULTS

As in the 1996 analysis, berm and undisturbed trees grew significantly (contrast $p<0.05$) more than inner track and midroad trees at the current block age in both total height and 3-year increment for pine (Figure 3, Table 2). In addition, the contrast on the 7-year measurements showed that diameter and volume were significantly greater in the berm and undisturbed trees for pine (Figure 4). In the analysis at block age 7 years, 3-year increment was significantly greater in the berm and undisturbed trees for both pine and spruce; additionally total height was greater for spruce. (Figures 5 and 6).

Compared to the 1996 analysis, one notable difference was detected: the growth of the inner track pine trees was significantly reduced compared to the trees in all other treatments, for all variables at the current block age (Figures 3 and 4), and for 3-year increment at the height at block age 7 (Figure 5). In the previous analysis, the trees were only 5 years old at the comparison age. The results at the plantation age of 7 years demonstrate a continuing trend of poorer tree growth on the inner track. In some cases, tree growth is worsening, particularly for pine, as demonstrated by the significantly reduced growth in diameter and volume on this treatment. Trees growing on the inner track location demonstrate the poorest growth of all treatments.

Mean 3-year increment growth from the 1999 measurement was compared to mean 3-year increment growth in 1996 (Figure 7) for each site/species/treatment combination.[2] Recent measurements show an increase in 3-year increment for all sites and treatments for both species over the previous measurement period. Some notable trends are apparent in the 7-year measurement data. The growth of the berm trees compared to trees at other skid road locations on calcareous sites (i.e., Lussier River and East Lussier Creek) is greater than it was 3 years ago, as is the growth for the undisturbed trees at Bloom Ridge. Additionally, the 3-year increment for the midroad trees for five of the nine site/species combinations (i.e., North Grave Creek Pl and Se,

1 East Lussier trees were six years old (the block age in 1999) in this analysis.
2 No statistical analysis was done on this variable.

TABLE 2 *Summary of ANOVA tables and contrast tests*

Variable	Obs.	Mean square error	DF numerator	DF denominator	F ratio	Prob>F		Contrasts—skid road location[a] B/U vs. I/M[b]	B vs. others	I vs. others
Current height										
							t Ratio	3.308	3.923	-2.426
Pl Total Height	1036	9760.08	3	24	5.810	0.004	Prob>|t|	0.003	0.001	0.023
							t Ratio	3.585	4.541	-2.384
Pl 3 Year Increment	1036	2481.62	3	24	7.348	0.001	Prob>|t|	0.001	0.000	0.023
							t Ratio	2.858	3.532	-2.487
Pl Diameter	1036	5.52	3	24	4.897	0.008	Prob>|t|	0.009	0.002	0.012
							t Ratio	3.131	3.700	-2.337
Pl Volume	1036	2755167.80	3	24	5.207	0.006	Prob>|t|	0.004	0.001	0.026
							t Ratio	2.003	2.320	-0.688
Se Total Height	511	2024.93	3	12	2.050	0.149	Prob>|t|	0.064	0.035	0.501
Height at block age 7										
							t Ratio	1.580	-2.051	1.793
Pl 7 Year Height	1036	2266.23	3	30[c]	1.886	0.143	Prob>|t|	0.120	0.045	0.079
							t Ratio	2.282	2.581	2.290
Pl 3 Year Increment	1036	992.46	3	30	3.042	0.036	Prob>|t|	0.026	0.012	0.026
							t Ratio	2.849	2.614	1.883
Se 7 Year Height	511	1030.73	3	12	3.164	0.052	Prob>|t|	0.012	0.019	0.252
							t Ratio	2.756	2.940	0.750
Se 3 Year Increment	511	303.22	3	12	3.634	0.027	Prob>|t|	0.011	0.007	0.461

a No experiment-wise error correction applied.
b Abbreviations for skid road locations are B-berm, U-undisturbed, I-inner track, M-midroad. 'Others' refers to the three other treatments combined.
c Data from Caven Creek sites (destructively sampled in 1995) are only included in Pl 7 year height test, hence different DF denominator value than in Pl current height contrasts.

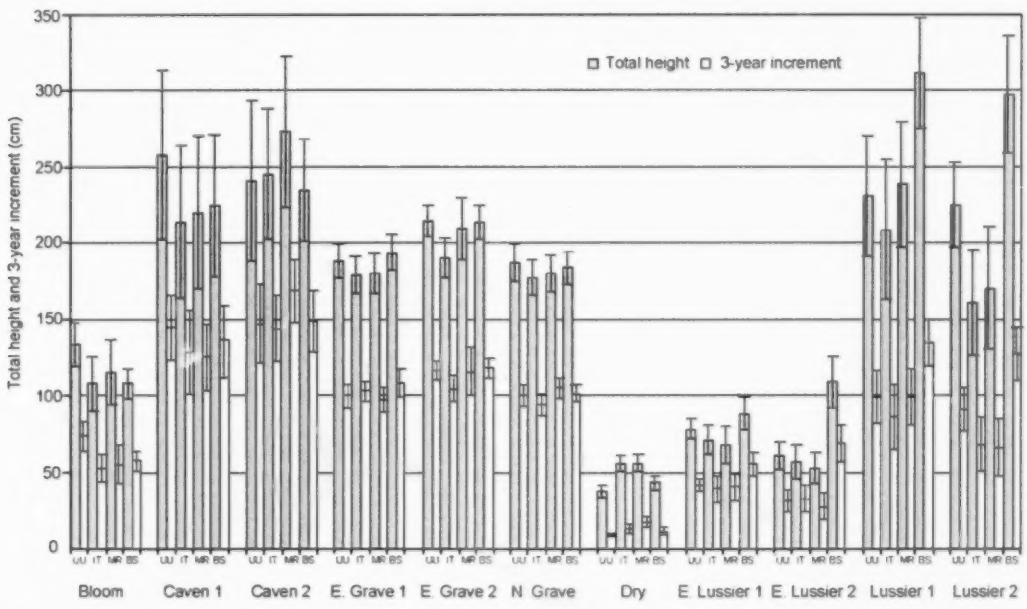

FIGURE 3 *Total height and 3-year increment for lodgepole pine (1999). Error bars represent 95% confidence intervals. UU = undisturbed; IT = inner track; MR = midroad; BS = berm/sidecast. Lower (1) and upper (2) skid road results are shown.*

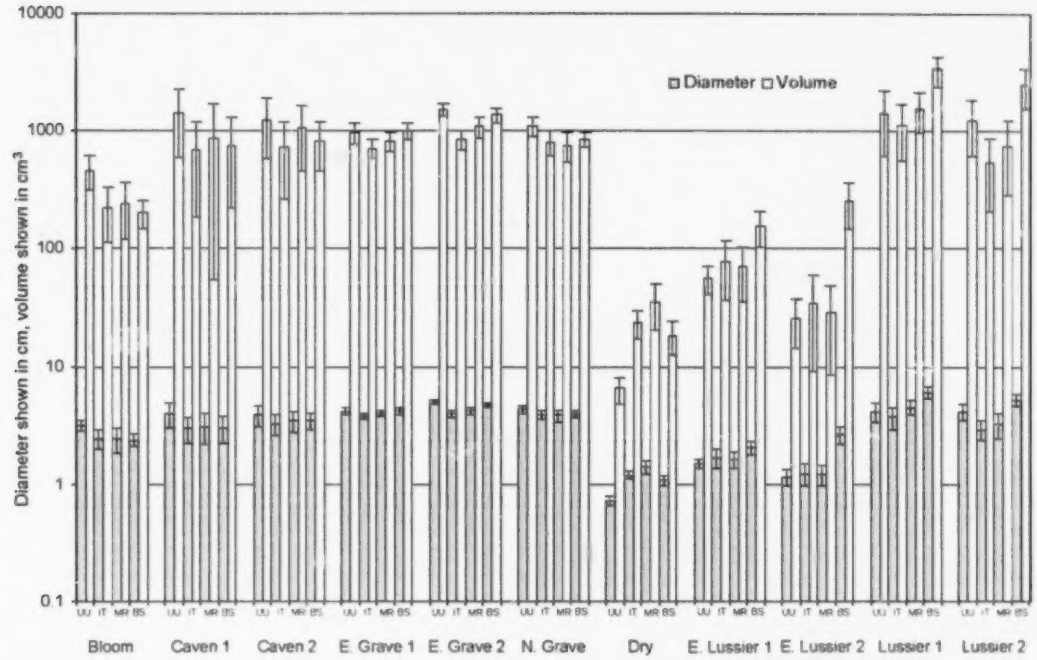

FIGURE 4 *Diameter and volume for lodgepole pine (1999). Error bars represent 95% confidence intervals. UU = undisturbed; IT = inner track; MR = midroad; BS = berm/sidecast. Lower (1) and upper (2) skid road results are shown.*

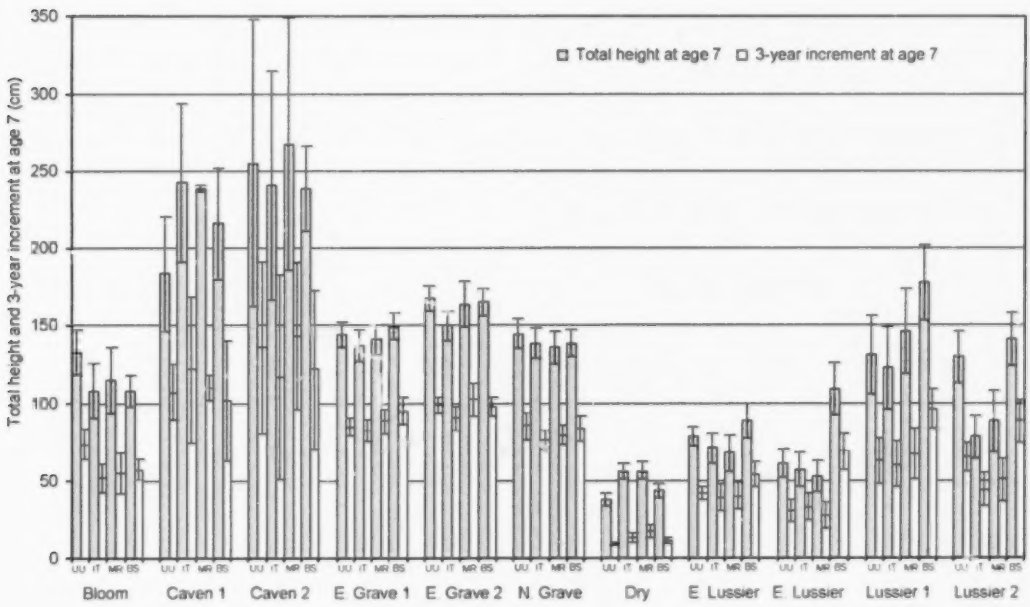

FIGURE 5 *Total height and 3-year increment at age 7 for lodgepole pine. Error bars represent 95% confidence intervals. UU = undisturbed; IT = inner track; MR = midroad; BS = berm/sidecast. Lower (1) and upper (2) skid road results are shown.*

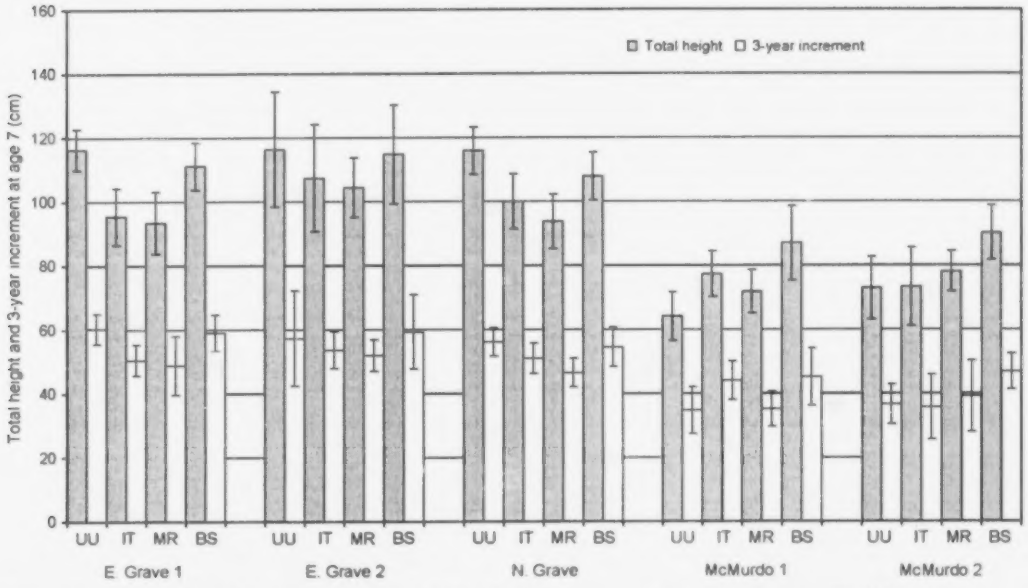

FIGURE 6 *Total height and 3-year increment at age 7 for Engelmann spruce. Lower (1) and upper (2) skid road results shown for East Grave Creek and McMurdo Creek. Error bars represent 95% confidence intervals. UU = undisturbed; IT = inner track; MR = midroad; BS = berm/sidecast. Lower (1) and upper (2) skid road results are shown.*

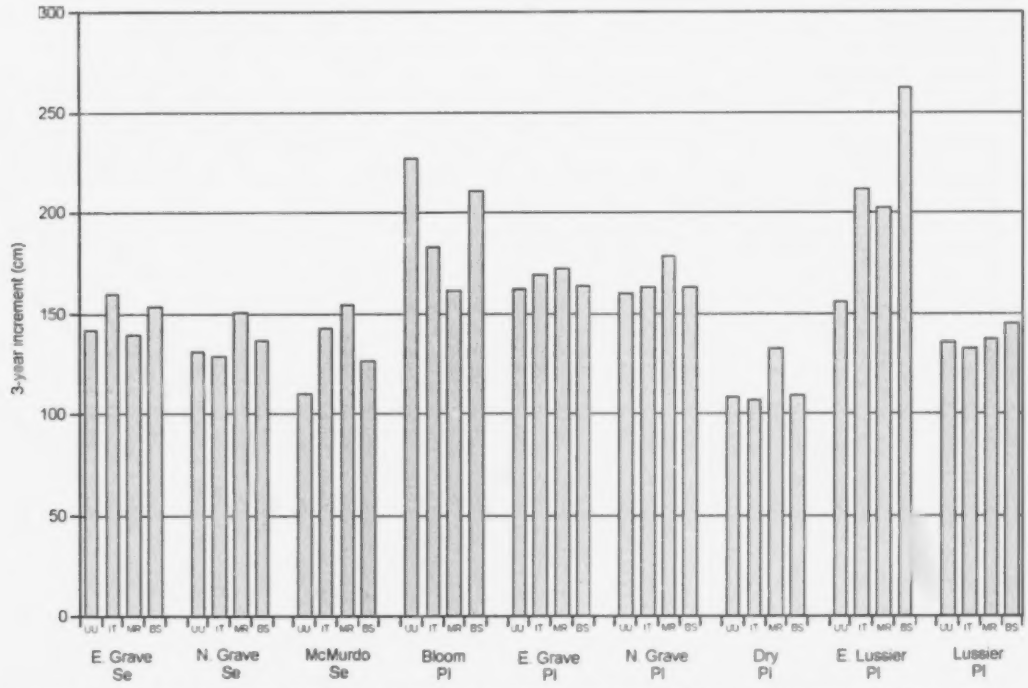

FIGURE 7 *Three-year increment (1999) as a percentage of 1996 3-year increment. UU = undisturbed; IT = inner track; MR = midroad; BS = berm/sidecast.*

East Grave Creek P1, McMurdo Creek Se, and Dry Creek P1) has increased more than the other treatments.

4 DISCUSSION

The growth differences between treatments may be attributed to one or more factors:

- skid roads effects, such as subsurface compaction;
- rehabilitation effects, such as altered soil organic matter and mixing with subsoil; or
- site-specific, growth-limiting factors, such as unfavourable substrates or competing vegetation.

Continued poor growth of the inner track trees at most locations compared to other treatments, coupled with the improved 3-year increment of the midroad trees over the period of this study, may be related to the treatment. The compacted running surface of the original skid road is intact under the recontoured slope, and may affect the growth of midroad trees and, to a lesser extent, inner track trees. Compaction effects are persistent. Previous studies on non-rehabilitated skid roads linked compaction to inferior root formation and growth (Wass and Smith 1994) and to significantly reduced tree growth in stands up to 15 years old (Smith and Wass 1979, 1980; Thompson et al. 1990). The worst compaction, and subsequently the most pronounced growth reductions, took place in the inner track. Root systems have a natural tendency to grow further down slope than up (Mead et al. 1991). In the case of rehabilitated skid roads, this downslope growth will eventually bring the root systems to undisturbed soils. The root systems of trees growing on the inner track are the most disadvantaged, requiring more root growth through the compact subsurface before coming into contact with the undisturbed soils down slope.

The recontoured sidecast material is an anthropogenic soil, amorphous in structure. The recontoured material varies in depth between sites and across the skid road, being deepest under the inner track treatment. Although changes in aeration porosity or hydraulic conductivity may have occurred during the excavation and rehabilitation of this soil (and should be considered), testing for this effect was beyond the scope of this study. A greater concern may be the available water storage capacity of the recontoured material. If this storage capacity is insufficient, inner track trees are again at the greatest disadvantage.

Differences in tree growth between treatments are most pronounced at the sites with calcareous soils (i.e., Lussier River and East Lussier Creek) (see Table 1). Smith and Wass (1994) demonstrated that soil disturbance related to the construction of excavated skid roads in a calcareous soil is associated with reduced tree growth. Because of their poor physical properties, alkaline pH, and the reduced availability of nutrients such as iron, phosphorus, and manganese, calcareous soils can have a negative effect on tree growth (Smith and Wass 1994; Curran and Maynard [2003]). This unfavourable substrate may be present in, or mixed into, the reconstructed topsoil of a rehabilitated skid road, which is recontoured with the excavated material (Kishchuk et al. 1999; Senyk and Wass 1999).

Other notable differences in growth between the treatments may be

associated with vegetation competition. Three of the nine site/species combinations do not conform to the general pattern of improved growth on the berm and undisturbed treatments compared to the inner track and midroad treatments. At two of these three study sites, vegetation competition is possibly affecting tree growth. For instance, at Bloom Ridge (planted with pine) all skid road locations, including the berm, have inferior growth compared to the undisturbed treatment. This skid road was seeded with grass before planting, and this seeding was still apparent at the 5-year remeasurement. Pine grows especially poorly in competition with grass (Lotan and Critchfield 1990). Spruce, on the other hand, is generally more tolerant of vegetative competition and shade (Alexander and Shepperd 1990). Yet, at McMurdo Creek, the spruce is growing more poorly in the undisturbed treatment than all other treatments. This is a high-elevation, cold aspect site with heavy brush cover (primarily false azalea [*Menziesia ferruginea*]). Most undisturbed trees are found under the brush canopy, which is considerably less dense on the skid roads. A site preparation effect may be apparent at McMurdo—the exposed soil of the skid road may warm more rapidly, benefiting the growth of the skid road trees.

The *Soil Rehabilitation Guidebook* (B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks 1997) defines successful skid road rehabilitation in terms of sustainable site productivity. However, according to Morris and Miller (1994), slow-growing stands require 20 or more years of growth before long-term productivity consequences can be ascertained. At plantation ages of 6–10 years, the trees in this study are still too young to make reliable predictions about long-term site productivity. The improvement in 3-year increment over time demonstrates how long-term predictions could vary during the early plantation years. Although the resolution of site index is poor at young stand ages, preliminary site index was calculated for all skid road locations and species to assess the efficacy of early rehabilitation methods at restoring site productivity. As expected, site productivity indices were lower on the skid roads (Curran et al. [2003a]). While it is too early to make any conclusive statements about sustained productivity on early skid road rehabilitation efforts, this research trial adheres to most of the conditions recommended for reliable inferences of long-term site productivity, including suitable replication, appropriate plot size, and contrasting treatments (Mead et al. 1991; Morris and Miller 1994). Experimental controls, such as pre-treatment plot information and between-treatment buffers, are unavailable because of the retrospective nature of this study. As such, while unequivocal results are not possible, 20-year site index measurements should yield more conclusive long-term predictions.

5 CONCLUSIONS

- In this study, trees grew significantly less on the inner track skid road locations compared to the berm and undisturbed locations.
- Trees growing on excavated and bladed trails that were recontoured without decompacting the skid road surface may suffer from the influences of subsurface compaction.
- Planting trees in a growing medium containing calcareous subsoils may have deleterious effects on tree growth.
- In some cases (e.g., the berm treatment), skid road rehabilitation may have ameliorative effects on site growth limiting factors. In this example,

rehabilitation represents a form of site preparation because the forest floor is still accessible to seedlings.

- Continued poorer growth observed on the skid roads in this study supports the FPC requirement for more intensive rehabilitation methods to restore site productivity. Until it is demonstrated that the construction and rehabilitation of skid roads is sufficient to support acceptable tree growth, net downs to Annual Allowable Cut calculations may be necessary to address reduced tree growth on temporary access structures.

6 RECOMMENDATIONS

1. Apply other required rehabilitation treatments in addition to the simple slope recontouring studied here. For instance, the Timber Harvesting Practices Regulation, Section 14 (B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks 1998) prescribes the following: decompacting trails, recontouring slopes with the sidecast material, re-establishing natural surface drainage, salvaging and replacing the original organic matter where possible, and mitigating erosion through revegetation and distribution of woody debris. These standards are being incorporated into best management practice documents such as the harvesting handbook (Curran et al. [2003b]). A video and field cards (Curran 1998) demonstrating these techniques are available.
2. Plant seedlings to maximize the use of areas with demonstrated productivity (i.e., the berm/sidecast and the adjacent undisturbed area above the skid road). Do not plant the inner track, particularly on unfavourable subsoil.
3. Remeasure the sites in this study in 2002 (10-year remeasurement) and continue monitoring into the long term.
4. Develop field trials to specifically test the effectiveness of current FPC requirements.

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